23. (Amended) The system of controlling functions in response to position information determined by ultra wideband impulse radio means of claim 20, wherein said function is a lighting means to illuminate an area wherein said position or object is located.

24. (Amended) The system of controlling functions in response to position information determined by ultra wideband impulse radio means of claim 20, wherein said function is an alerting means to alert said person or object of an unsafe position.

25. (Amended) The system of controlling functions in response to position information determined by ultra wideband impulse radio means of claim 19, wherein said controller is a microprocessor.

Remarks

Reconsideration of the application is respectfully requested.

Upon entry of the foregoing amendment, claims 1-25 are pending in the application. These changes are believed to introduce no new matter, and their entry is respectfully requested. Based on the above amendment and the following remarks, Applicants respectfully request that the Examiner reconsider all outstanding objections and rejections and that they be withdrawn.

Summary of claim Rejections

Claims 1, 2, 6, 10, 15, 19-22, 24-25 are rejected under 35 U.S.C. 102(b) as being anticipated by Jandrell. Claims 3-5, 7-9, 11,13, 14, 16-18, and 23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Jandrell in view of Snaper.

Summary of Amendment

Applicants have amended claims 1,6, 19-25. Inventorship modification is not required pursuant to 37 C.F.R. 1.48(b) as all inventors are still inventors of a least one claim remaining in the application.

Claims 1,6, 19-25 have been amended to include the clarifying language of "ultra wideband" to claim the impulse radio transmitters and receivers. Thus, "impulse radio transmitters" are now "ultra wideband impulse radio transmitters". Further, "impulse radio receivers" are now "ultra wideband impulse radio receivers".

Remarks regarding §102 rejection

To reject all claims 1-25 under 35 U.S.C. 102(b) and 35 U.S.C. 103(a), the Examiner relies on Jandrell (US 5,526,357). The understandable fundamental flaw with this rejection is definitional. Although the terminology is similar, the impulse transponder unit and associated internal clock means associated with said transponder unit and based impulse transceiver of Jandrell is distinct from the impulse radio transmitter and clocking means and impulse radio receiver of the present invention. The impulse transponder of Jandrell uses a carrier wave (i.e., transponder) to propagate the "coded carrier pulse" (please see col. 6, line 18-25). Further, in the Jandrell patent, the

synchronization is made to a master base station and maintains a stable interval to accommodate jitter. See col. 16, line 58-64. Thus, using a master and slave situation Jandrell uses a multi-measurement averaging scheme to average out effects of jitter. Please see cols. 53 and 54. This is required because of the inaccuracies associated with the transponder technology as opposed to the highly accurate timing mechanisms of the ultra wideband impulse radio of the present invention. That is, the impulse radio as defined in the present invention as opposed to the impulse radio as defined by Jandrell. It is beneficial to understand the differences between transponder technology (which is carrier based) and impulse technology of the present invention, thus the following is a basic review of transponder technology.

Transponders were originally electronic circuits that were attached to some item whose position or presence was to be determined. The Transponder functioned by replying to an interrogation request received from an interrogator, either by returning some data from the transponder such as an identity code or the value of a measurement, or returning the original properties of the signal received from the interrogator with virtually zero time delay, thereby allowing ranging measurements based on time of flight. As the interrogation signal is generally very powerful, and the returned signal is relatively weak, the returned signal would be swamped in the presence of the interrogation signal.

The functioning of the Transponder was therefore to move some property of the returned signal from that of the interrogation signal so that both could be detected simultaneously without the one swamping the other. The most common property to change is the transmission frequency meaning that the transponder might receive the interrogation frequency at one frequency, and respond on another frequency that is

separated sufficiently with regard to frequency so that both may be detected simultaneously.

Transponders were initially used in World War 2 on aircraft to identify the aircraft using IFF (Identify Friend or Foe), where friendly aircraft would respond to secret preprogrammed interrogation codes and indicate to the radar operators that they were friendly aircraft. Today Transponders are still used extensively on commercial aircraft to relay to the radar operators the height and identity of the aircraft on their radar displays.

Another important use for transponders has been in the measurement of distance. Here the interrogator sends a signal to the transponder, which immediately responds on another frequency. By measuring the time from the sending of the initial signal by the interrogator, to the receipt of the signal from the transponder, and calculating the effective double path traveled using the speed of light, the distance between the transponder and the interrogator can be determined. The accuracy of such systems is limited to fractions of a meter using electromagnetic propagation systems due to the limits in determining the transmission times with sufficient accuracy. (A system called Tellurometer invented in the 1960's improved this resolution over distances of 100's of kilometers to a few centimeters, but although this still used transponders, it was not based on the principle of time of flight).

Transponder systems have recently started to become major players in the field of electronic identification. Within this application, it is necessary to make the transponders as cheap as possible, and to rather build the sophistication into the readers. This lack of sophistication generally means that changing the transmission frequency is no longer an

option, as the frequency translation needs expensive and complex tuned circuitry. Instead the transponders have given up the ranging ability and rather time slice the communications channel with the interrogator. Here the interrogator (called a reader) sends an interrogation signal for a limited time. The transponder receives the signal and waits for its completion, and then responds on the same frequency with its identity and data code. The devices are sometimes called transponders and are also sometimes called tags, most probably because their end application eventually will be the tagging of goods.

Jandrell creatively uses placing an impulse separated by more than twice the delay spread to help avoid multipath interference, which also results in a limited impulse rate of about one pulse each six microseconds, or about 160,000 pulses per second (col. 5, lines 32-36). He overlays these pulses on the carrier frequency and uses the measurement of the delay spread. "The method involves the transmission of a noise-like pulse-burst and reconstruction of the delay envelope from the received signal by correlation techniques in the receiver" (col. 38. lines 64-67). The Examiner's attention is drawn to Fig. 18, wherein Jandrell illustrates the IF-frequency pulse 1600 being overlayed on the transmitted RF-frequency spread pulse 1610 with the propagation delay of 5 microseconds. The received pulse 1620 uses the detection delay (which is equal to the time-of-flight plus de-correlation time plus equipment delay). Following the reception of the carrier (Transponder signal) modulated by the exciting IP-frequency impulse, a threshold detector 1630 detects the decorrelated IF-Ouptput pulse. By doing this, the arrival instant can be determined and thereby the time of flight. However, by detecting the delay spread and the limited number of transmitted pulses (160,000) the accuracy and

robustness is limited. Further, a constant interval is used due to the inability to very the listening interval as can be accomplished in the present invention.

Further, the Examiner's attention is drawn to Figure 23, which describes the implementation with respect to the pulse placement and the transmitted spread pulse symbols. Note the relatively inaccurate placement of the pulses which thereby require a delay spread to determine time of flight and thereby positioning. As was disclosed in the present application and as will be articulated below, the present application through the use of the techniques therein is capable of, for example, 10 million pulses per second and superior positioning abilities. It is also noted that the pulses in Jandrell are positioned on a carrier, making them narrowband signals, which is another significant difference from the ultra-wideband technology of the present application. As Jandrell states himself, "Generating a short duration pulse requires a correspondingly large bandwidth, and bandwidth is always a very scarce commodity. Therefore, a practical system would necessarily be implemented with lower power and would have to use the available, limited bandwidth ..." Time Domain, the assignee of the present invention, has taken a very contrary approach. They have not restricted their technology to narrowband signals on a carrier. This is the typical approach because the Federal Communication Commission (FCC) assigns spectrum. Thus, the using of the traditional spectrum paradigm, spectrum indeed is very scarce. However, using the ultra wideband technology of the present invention, spectrum is not scarce, quite to the contrary, a large swath of the spectrum is used and can be re-used simultaneously by many users. By using the techniques described in detail in the present invention and in the patents and patent applications incorporated in the present application by reference, an ultra

wideband carrier wave-less, highly accurate ultra-wide band asset tracking system has been described.

To further articulate the difference between narrowband transponder with pulses overlaid creating a delay spread for time of flight and thereby distance determination technology from the ultra wide band technology of the present invention, the Examiner's attention is referenced to page 8 of the present invention. This is the impulse radio (also known as ultra wide band) basics section. In the first subpart of the impulse radio basics section is described the Gaussian monocycle that models the ultra wide band pulse and the pulse modulation techniques. Please note that this pulse is a carrier wave-less pulse and therefore has wideband frequency components. Also, described is the pulse modulation techniques such as AM, time shift and M-ary versions.

The applicant of the present invention, in anticipation of confusion of narrowband pulsed carrier prior art, states at the end of page 8, "Generally, conventional spread spectrum systems make use of pseudo-random codes to spread the normally narrow band information signal over a relatively narrow band of signals." A conventional spread spectrum receiver correlates these signals [please note Jandrell's correlation in FIG. 23, illustrated as correlator #11 and correlator #01] to retrieve the original information signal [precisely what Jandrell accomplishes]. Unlike conventional spread spectrum systems, the pseudorandom code for impulse radio communication is not necessary for energy spreading because the moncycle pulses themselves have an inherently wide bandwidth. Instead, "the pseudo-random code is used for channelization, energy smoothing in the frequency domain, resistance to interference and reducing the interference potential to nearby receivers."

The waveforms are illustrated on page 9 which have wideband frequency components and transmitted through the ether without the use of a carrier frequency. The impulse radio basics section goes on to describe the pulse train, coding for energy smoothing and channelization, modulation, reception and demodulation, interference resistance, processing gain, multipath and propagation and finally distance measurement, and exemplary transceiver implementations including impulse radio transmitters and receivers. Even without reviewing each of these sections in detail, it is apparent that ultra wide band and the ability to accurately place and transmit pulses without a carrier frequency and then coherently detect them in a receiver at a rate of, for example, ten million pulses per second [as opposed to 160,000 for Jandrell] is specific to ultra wide band and significantly different from delay envelope detection. Thus, ultra-wide band enables a far more robust system with much better accuracy and far great multipath immunity.

To further articulate the significance of a carrier wave based signal, with its inherent limitations and inaccuracies, such as Jandrell, with a carrier wave-less signal of the present invention, a discussion of the distinctions follow.

History

By the 1920's, the basic architecture used in modern radio systems was largely in place. At the transmitter, the output of a radio frequency (RF) oscillator was modulated by some desired signal, and the resulting modulated carrier was fed to a transmit antenna. At the receiver, the signal from the receive antenna was "heterodyned", or "mixed", with a local copy of the carrier to retrieve the desired signal.

Certainly many improvements have been made to this basic architecture since that time. Improvements in components allowed radios to operate at increasingly higher frequencies. The resulting shorter wavelengths allowed practical directional antennas that could be aimed or pointed. The introduction of the transistor and solid-state devices allowed much greater complexity and reliability at lower cost and lower power consumption, and various forms of modulation and methods for increasing signal bandwidth have resulted in increased data rates and channel capacity. But, even with these many improvements, traditional radio systems are generally conceived in the same terms: a transmitter consisting of a modulated RF carrier signal and a heterodyne receiver to remove the carrier and retrieve the signal.

With the earliest efforts dating back to at least the early 1950's, a "carrier-less" radio technology has also evolved, which is known today as ultra-wideband (UWB) technology. For a variety of technical and regulatory reasons, UWB technology has, to a large extent, been limited to the laboratory. And, as a consequence, the average person is generally unfamiliar with UWB. Furthermore, because much of the terminology that has been applied to UWB was derived from terminology used to describe traditional carrier wave-based radio technology, and because these technologies are generally used for the same general purposes (e.g., communications, radar, and positioning), the concepts and methods used to practice the two technologies might be assumed to be similar or even interchangeable. However, carrier wave-based pulse signals are fundamentally different from carrier-less UWB pulse signals. In fact, their waveforms are completely different, the means for producing them are completely different, and the means for receiving them and producing the environment multipath response are completely different. Thus, in

many significant areas, UWB systems are radically different from traditional carrier wave-based systems, and UWB and narrowband concepts and methods are fundamentally incompatible. Although some narrowband ideas can be applied for use in a UWB system, they generally require the benefit of significant modification and invention for them to be reduced to practice. Many other carrier wave-based radio technology concepts simply do not apply to UWB technology.

Differences in the Waveforms

A carrier wave-based pulse waveform has a carrier having some narrowband frequency and typically has a very long duration, for example, on the order of 10-20 microseconds. While sometimes referred to as a transmitted pulse, in fact it has the physical properties of a continuous wave or narrowband signal (many periodic zero crossings and a constant envelope). Furthermore, in Jandrell the so-called "pulse" duration is longer than the delay spread. In contrast, a UWB waveform uses no carrier; the transmitted signal is entirely "baseband." The signal bandwidth is an order of magnitude or more beyond that of carrier wave-based waveforms. It is typically less than one nanosecond in duration and its duration is always much less than the delay spread. These fundamental differences are closely related to both the different means used to produce and receive the waveforms as well as the effects of superposition at the receiver.

Although certain forms of carrier wave-based systems, such as spread spectrum systems, may be called wideband because their RF bandwidth is wide relative to their data rate or symbol rate, the RF bandwidth is only 2% or less relative to the center frequency of the carrier. Thus, these forms of wideband signals have the same

characteristics of any narrowband signal, which consists of many cycles (i.e., repeated segments of the waveform) having similar zero crossing durations and similar amplitudes. In contrast, a UWB signal has typically an RF bandwidth of 100% relative to the center frequency. This results in a waveform that has no repeated segments and is thus completely different than wideband waveforms.

Differences in the Means for Producing the Waveforms

Unlike a carrier wave-based transmitter, a UWB transmitter does not drive an antenna with a signal having some carrier frequency. Instead, a UWB system typically generates its transmitted waveform from a baseband signal or symbol, which triggers or excites a monocycle impulse waveform generator.

The characteristics of UWB waveforms place severe demands on the performance of system components like antennas and generally require fundamentally different antennas and means for exciting them. Antennas used with narrowband systems are typically not adequate because they do not behave uniformly over the significantly wider bandwidth. Much creativity and invention are required to devise efficient UWB antennas.

There are also fundamental differences in how carrier wave-based signals and UWB signals behave in regards to antenna arrays. For example, a narrowband antenna array suffers from grating lobes whenever antenna elements are placed more than a half wavelength or so apart. This is because each of the subsequent cycles of a continuous wave has an opportunity to add up constructively in unintended directions. In contrast, because the short pulse signals from a UWB array are inherently limited in time, they do

not exhibit this behavior and UWB arrays can be made with more sparsely spaced elements than narrowband practice normally allows.

Differences in the Means for Receiving the Waveforms

Unlike a traditional radio receiver, a UWB receiver does not heterodyne a local oscillator signal with the received signal. Because there is no carrier present, down conversion to remove a carrier is not required. Rather, a UWB receiver samples the received signal and constructs a copy of the received waveform. In an ideal case, a conjugate matched template is correlated, or mixed, with the received signal. This method is the UWB analog of heterodyning with a carrier wave, where the matched template comprises a sequence of time-spaced template signals used to coherently sample the received signal an thereby directly convert it to a baseband signal. Alternatively, a UWB signal can be non-coherently sampled in the same manner as an oscilloscope or non-coherently detected using a threshold detection approach.

One fundamental difference is that carrier wave-based signal receivers typically use a significant portion of the multipath received waveform in the detection process, while a UWB waveform is processed by a sampling means at one or more distinct points in the received multipath waveform.

Another fundamental difference between carrier wave-based signals and UWB signals are the effects of superposition at the receiver. The multipath components of a received signal are linearly added at the receiving antenna by the principle of superposition. When the multipath components of a narrowband signal are combined at the antenna, the effect is that various time delayed (and thus phase-shifted) points of the

cyclical waveform are added, creating a received waveform signal at the antenna terminals having unpredictable amplitude and apparent phase. This is a result of the essentially continuous duration (i.e., very long duration relative to both the delay spread and the symbol rate) of the narrowband waveform propagating in the environment and its repetitive waveshape so that voltages arriving from many different length paths in the environment are added together simultaneously at the antenna. Besides the unpredictable received amplitude, as mentioned, which makes reception less robust, this signal also loses the information of the true direction of arrival of the signal from transmitter to receiver, due to the mentioned unpredictable phase. In contrast, a received UWB signal is composed of a time history of received signals where there is no possibility of simultaneous reception of different segments of the waveform, since the waveform has a very short duration relative to the delay spread. The effect is that received amplitude at the antenna terminals is not affected by earlier or later arriving signals, and also, the true direction from transmitter to receiver is preserved at the point of reception.

The methods used to acquire and track a carrier wave-based signal over time are analogous but fundamentally different than the methods used for a UWB signal. Where a conventional phase lock loop tracks phase from cycle to cycle, a UWB lock loop is a time domain equivalent of a conventional phase lock loop that tracks timing from pulse to pulse.

Remarks regarding §103 rejection

As was the case with Jandrell, Snaper pertains to carrier wave based systems and when combined with Jandrell, the present invention remains non-obvious for the reasons articulated above.

Conclusion

All of the stated grounds of objection and rejection have been properly traversed, accommodated, or rendered moot. Applicants have shown that although at first blush the terminology may seem similar (e.g., varying the duty cycle of a transponder vs. varying the duty cycle of an impulse radio impulse radio as defined in the present invention) between the cited art and the present invention, when the specification is reviewed to show the definitions of this terminology, the cited art is easily distinguished. Applicant has modified the claims to more clearly relate the definitional distinctions by replacing impulse radio with ultra wideband impulse radio. Further, in the above discussion the significant differences between a carrier based system and an ultra wideband system which is a carrier wave-less system were related to help understand the differences and concomitant improvements of the present invention.

Applicants therefore respectfully request that the Examiner reconsider all presently outstanding objections and rejections and that they be withdrawn. Applicants believe that a full and complete reply has been made to the outstanding office Action and, as such, the present application is in condition for allowance. If the Examiner believes, for any reasons, that personal communication will expedite prosecution of this application the Examiner is invited to telephone the undersigned at the number provided.

Prompt and favorable consideration of this Amendment and Reply is respectfully requested.

Respectfully submitted,

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